be called the eutectic level because the additional temperature necessary to fusion would there be a minimum. The question then arises what relation may be supposed to exist between the eutectic level and the level of compensation.

In computing the temperature distribution of a cooling globe which owes a part of its heat to compression, or to initial temperature, and another part to radioactivity, it is necessary to proceed by trial and error, or to test various assumptions and consider which best fits the facts. I have assumed various ages and computed other conditions corresponding to the actual heat emission of the globe. These other conditions are the depth of the eutectic level, the thickness of the radioactive shell (supposed uniform) and the proportion of the surface gradient due to radioactivity. Two cases are of special interest, the assumed ages being 68 million years and 1,314 million years.

For the lower age the eutectic level is at a depth of 121 kilometers, and thus coincides with Hayford's compensation level, the radioactive layer is 2.58 kilometers thick and radioactivity supplies $\frac{1}{7}$ of the surface gradient or of the earth's heat emission. For an earth 1,314 million years old the eutectic level lies at 300 kilometers, the radioactive layer is 12 kilometers thick and just $\frac{2}{3}$ of the surface gradient is due to radioactivity. In this ancient earth the highest temperature excess due to radioactivity would be found at and below the bottom of the active layer and would amount to only 106°. This is not much in comparison with the temperature of lavas and, if this age is the highest worth considering, most of the earth's heat must be due to compression.

So great an age as 1,314 million years seems incompatible with other features of the problem. This age implies that a thick shell extending from the compensation level downward to and beyond the eutectic level, a shell more than 200 kilometers in thickness, has cooled after solidification through an average temperature interval of about 600°. Now the geodesists have shown that at the compensation level the strains must be small, and I have given reason for believing these strains even smaller than those computed by the geodesists. But I hold it impossible that a layer of rock 200 kilometers thick can cool 600° without setting up large strains.

On the other hand, no such difficulty arises in the case of an earth 68 million years old, for it is easy to show that only a very small amount of cooling has occurred below its eutectic level. Furthermore, in this case the level of compensation acquires a definite and intelligible physical interpretation. Local fusion would bring about compensation. Where, then, should we look for compensation if not at the eutectic level?

In such speculations as this some latitude must be allowed. If, as the geodesists suspect it may be, the compensation level is as deep as 140 kilometers, and if this is also the eutectic level, the earth is 100 million years old, the radioactive layer is 4.74 kilometers thick and 26 per cent. of the heat emitted by the earth is of radioactive origin.

It has often been asserted that the discovery of radioactivity indefinitely prolongs the probable age of the earth. To me it seems that the determination of the level of compensation limits both the age of the earth and the amount of radioactive matter in its outer shell.

George F. Becker
U. S. Geological Survey

The Constitution of the Atom[1]

The subject of the constitution of the atom has come into extreme prominence—great ad-

[1] From the address of the president of the Royal Society, Sir William Crookes, at the anniversary meeting on November 30, and printed in *Nature*.

vances have been made—while much light has been thrown on the ultimate structure of matter. Years ago, during the persistent and systematic fractionation of yttrium, I explained that I had succeeded in separating the atoms of the so-called elements into groups; these groups undoubtedly exhibited different phosphorescent spectra and presumably had different atomic weights—although from the chemical point of view all the groups behaved similarly. I concluded that, of the lines and bands of the compound spectrum of an element, some are furnished by certain atoms and some by others. I pointed out that this was not likely to be an isolated case; that probably in all so-called elements the whole spectrum does not come from all the atoms—that different spectral rays come from different atoms, which may be interpreted to mean that there are definite differences in the internal motions of the several groups of which the atoms of a chemical element consist. I ventured to suggest a possible explanation of these facts, based on the assumption that acting on the original *protyle* were two forces—one of the character of time, accompanied by a lowering of temperature, while the other, swinging to and fro like a pendulum, and having periodic cycles of ebb and flow, rest and activity, would be intimately connected with the force of electricity. I arrived at a presentation of the elements on a lemniscate path which seemed to me to throw some light on the question of their genesis. My researches seemed to show that the persistence of the ultimate character, the eternal self-existence, the fortuitous origin of the chemical elements, could no longer be regarded merely as probable.

Apparently bodies exist which possess close upon the same atomic weights and combine in definite proportions with other substances and yet exhibit certain minute differences. For these substances, which are capable of being isolated and identified, I suggested the name "meta-elements." Thus there appears to me to be a gradation of molecules of different ranks between the atom and the compound—and these aggregations of atoms in certain circumstances might well pass for simple elementary bodies.

In recent years the old idea of the ultimate atom as a solid particle, spherical or otherwise, has slowly, almost imperceptibly, given way to the more rational conception of a minute planetary or "Saturnian" system of dazzling complexity; the conception is many-minded, aided here and there by facts that failed to fall in with the old lines of thought. Among the most prominent men through which the new conception has come to light, we have Kelvin, Stoney, Thomson, and, more recently, headed by Sir Ernest Rutherford, a host of vigorous workers in the new science of radioactivity, who have built up a conception of atomic physics often "hard to be understood," but that probably is a move in the right direction. Sir Ernest Rutherford supposes the atom to be composed of a nuclear positive charge, exceedingly small compared with the sphere of action of the atom, and consisting of a number of unit charges. Surrounding this nucleus is an external shell in which a number of separate negative electrons are distributed. Professor Soddy—whose name is closely associated with that of Sir Ernest Rutherford—is one of the earliest workers in radioactivity, and has developed a theory of the chemistry of the radio-elements based upon the periodic law and a modified form of lemniscate spiral where the existence of *pseudo*-elements having slightly different atomic weight but identical chemical properties are set out. These "isotopic" elements occupy the same place in the periodic table. He has thus arrived, by a totally different path from the one I traveled, at the conception of an element having atoms of different weight though chemically identical. The theory has recently received some confirmation by the analyses of the lead that is found in the minerals pitchblende, thorianite, etc. In my own laboratory a spectroscopic examination of the lead from Cornwall pitchblende has shown traces of thallium not found in pure assay lead; the unexpected presence of this element may have some bearing on the slightly different atomic weight values recorded for the lead extracted from the radio-minerals.

Without risking a charge of being unduly optimistic I think I may believe we are on the

brink of striking developments in our knowledge of the structure of the elusive atom. Whatever may be the outcome of researches now prosecuted with so much zeal and success, I feel that Addison was speaking with the voice of prophetic truth when, more than a hundred years ago, he said:

> Every atom is a standing miracle and endowed with such qualities as could not be impressed upon it by a Power and a Wisdom less than infinite.

SCIENTIFIC NOTES AND NEWS

THE colleagues of Professor Theobald Smith on account of the impending severance of his connection with Harvard University after a service of twenty years to become a member of the Rockefeller Institute of Medical Research, are arranging to present a bas-relief of Professor Smith to the medical school and reductions of this will be made and presented to each donor of $10 or more to the fund. A complimentary dinner will be given to Professor Smith on April 17.

A "GORGAS MEDAL" to be given yearly in honor of Surgeon-General Gorgas has been established by the medical reserve corps, U. S. army, New York state division. This medal is open to competition to members of the medical corps of the United States army, to medical reserve corps of the army and to members of the medical corps of the organized militia. Officers may submit papers on any subject of a medico-military nature.

THE Cornell Society of Civil Engineers held on January 22 in New York City its tenth annual dinner and reunion. The chief guest was Professor Charles D. Marx, of Leland Stanford Junior University, who has recently been elected president of the American Society of Civil Engineers.

DR. J. SCOTT KELTIE, secretary of the Royal Geographical Society, has been awarded the Cullum gold medal of the American Geographical Society.

THE Academy of Natural Sciences of Philadelphia has elected as correspondents Frank Dawson Adams, of Montreal, and Alfred Werner, of Zurich.

DR. H. E. ROBERTSON, of the University of Minnesota, is working in Professor Aschoff's laboratory and clinic at Freiburg, Baden. He reports himself as the only foreign student at present in attendance. The staff of over thirty members has been reduced to five and the number of students from 130 to 40.

THREE physicians of forty who took the recent civil service examination for the position of director of public health education, in the city of New York, have been placed on the eligible list, and President Henry Moskowitz of the municipal commission is reported to have said that an appointment will be made within a few days by Health Commissioner Goldwater. The eligible candidates are: Dr. Ira S. Wile, Dr. Winthrop Talbot and Dr. Charles F. Bolduan.

THE Fenger Fellowship of $600 for 1915 has been assigned to Dr. George L. Mathers, of the resident staff of the Cook County Hospital, Chicago, who will carry on work on certain bacteriological problems in pneumonia.

MR. GEORGE P. VANIER, of Steelton, Pa., has been awarded a certificate of merit by The Franklin Institute, Philadelphia, Pa., for his potash bulb. This bulb has been particularly designed for use in the determination, in industrial laboratories, of the total carbon in iron or steel. Mr. Vanier is chief chemist of the Pennsylvania Steel Co., Steelton, Pa. He has also designed zinc tubes and sulphuric acid bulbs for use in connection with the Vanier combustion train for the determination of carbon in steel by the direct combustion method with the electric furnace.

PROFESSOR ARTHUR KEITH, conservator of the museum at the Royal College of Surgeons of England, will deliver, during the latter part of March, a course of five lectures on the bearing of recent discoveries on our conception of the evolution and antiquity of man.

COLONEL GEORGE W. GOETHALS, who has been appointed Stafford Little lecturer on public affairs at Princeton University for this year, delivered an illustrated lecture on the Panama Canal at Princeton on Wednesday evening, January 27, in Alexander Hall. Owing to the